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Chapter Twelve
GEOMETRIC DESIGN TABLES

12 GENERAL

This chapter presents summary tables of the Department's criteria for the geometric design of State projects. The designer should consider the following in the use of the tables:

1. Functional Classification. Figure 12-1 illustrates the designated functional classification of State highways in Montana. To determine the latest functional classification of a facility, the designer should contact the Rail, Transit and Planning Division. The selection of design values depends on the functional classification of the highway facility. Note that, in general, National Highway System facilities within the current Federal-aid system will be designed using the freeway table (Figure 12-2) and the rural/urban principal arterial tables (Figures 12-3 and 12-7). As discussed in Section 8.2, arterials and collectors are approximately equivalent to primary and secondary facilities within the former Federal-aid system.

2. Manual Section References. These tables are intended to provide a concise listing of design values for easy use. However, the designer should review the Manual section references for more information on the design elements.

3. Footnotes. The tables include many footnotes, which are identified by a number in parentheses (e.g., (6)). The information in the footnotes is critical to the proper use of the design tables.

4. Controlling Design Criteria. The tables provide an asterisk to indicate controlling design criteria. Section 8.8 discusses this in more detail and presents the process for approving design exceptions to controlling criteria.

5. Local Agency Criteria. The roads and streets agencies within Montana's counties and cities may have developed their own geometric design criteria for local facilities. If a facility is not on the State highway system, it may be acceptable to use the local agency criteria where there are conflicts with the MDT criteria. This decision will be made on a case-by-case basis.

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MONTANA FUNCTIONAL CLASSIFICATION SYSTEM

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MONTANA FUNCTIONAL CLASSIFICATION SYSTEM
Figure 12-1

Figure 12-2

GEOMETRIC DESIGN CRITERIA FOR FREEWAYS
(National Highway System — Interstate)

	Design Element		Manual Section	Rural			Urban
Design Controls	Design Forecast Year (Geometrics)		8.4	20 Years			20 Years
	*Design Speed	Level	8.3	110 km/h			80 km/h
		Rolling		100 km/h			
		Mountainous		80 km/h			
	Level of Service		8.4	B			B
Roadway Elements	*Travel Lane Width		11.2	4 @ 3.6 m			4 @ 3.6 m
	*Shoulder Width	Outside Shoulder	11.2	3.0 m (1)			3.0 m (1)
		Inside Shoulder		1.2 m (2)			1.2 m (2)
	Cross Slope	*Travel Lane	11.2	2%			2%
		Shoulder		2% (3)			2% (3)
	Median Width	Level	11.3	Minimum: 11 m			Desirable: **11 m** Minimum: 5 m (4)
		Rolling		Minimum: 11 m			
		Mountainous		Desirable: **11 m** Minimum: 5 m (4)			
Earth Cut Sections	Inslope		11.4	6:1 (Width: 1.8 m)			6:1 (Width: 1.8 m)
	Ditch	Width	11.4	3.0 m Min.			3.0 m
		Slope		20:1 towards back slope			20:1 towards back slope
	Back Slope; Cut Depth at Slope Stake (5)	0 - 1.5 m	11.4	5:1			5:1
		1.5 m - 3.0 m		Level/Rolling: 4:1; Mountainous: 3:1			3:1
		3.0 m - 4.5 m		Level/Rolling: 3:1; Mountainous: 2:1			2:1
		> 4.5 m		Level/Rolling: 2:1; Mountainous: 1.5:1			1.5:1
Earth Fill Slopes	Fill Height at Slope Stake (6)	0 - 3.0 m	11.4	6:1			6:1
		3.0 m - 6.0 m		4:1			4:1
		6.0 m - 9.0 m		3:1			3:1
		> 9.0 m		2:1			2:1
Alignment Elements	DESIGN SPEED		N/A	80 km/h	100 km/h	110 km/h	80 km/h
	*Stopping Sight Distance	Desirable	8.6	**140 m**	**210 m**	**250 m**	**140 m**
		Minimum		120 m	160 m	180 m	120 m
	*Minimum Radius (e = 8.0%)		9.2	230 m	395 m	505 m	230 m
	*Superelevation Rate (7)		9.3	e_{max} = 8.0%			e_{max} = 8.0%
	*Vertical Curvature (K-value)	Crest	10.5	D: **49** M: 36	D:**110** M: 64	D: **155** M: 81	Desirable: **49** Minimum: 36
		Sag		D: **33** M: 27	D: **52** M: 38	D: **63** M: 49	Desirable: **33** Minimum: 27
	*Maximum Grade	Level	10.3	3%			5%
		Rolling		4%			
		Mountainous		5% (8)			
	*Minimum Vertical Clearance (9)		10.6	5.35 m			5.35 m

* Controlling design criteria (see Section 8.8). D: Desirable M: Minimum

GEOMETRIC DESIGN CRITERIA FOR FREEWAYS
(National Highway System — Interstate)

Footnotes to Figure 12-2

(1) Outside Shoulder Width. In mountainous terrain, these may be reduced to a 1.8 m minimum width where costs would be prohibitive to provide wider shoulders.

(2) Inside Shoulder Width. The following will apply:

a. For 3 or more through lanes in one direction, inside shoulders will be 3.0 m wide.

b. Where continuous curbs are used in narrow medians on ramps, the inside shoulder should desirably be 0.5 m and a minimum of 0.3 m.

c. Where vertical elements (other than abutments, piers or walls) in the median are more than 0.3 m high, the minimum offset from the edge of travel lane to the element is 1.2 m.

(3) Shoulder Cross Slope. Existing shoulder slopes on existing freeways may be 3.75%. If the proposed pavement work is resurfacing, the existing 3.75% slope may be retained. If the proposed pavement work is full-depth reconstruction or major rehabilitation, the shoulder slope should match the cross slope of the traveled way, typically 2%.

(4) Minimum Median Width. The minimum median width of 3.0 m may be used in urban areas with high right-of-way costs and in rugged mountainous terrain. It may also be used on any long and unusually costly bridges.

(5) Cut Slopes (Rock). The back slope through rock cut sections will be determined by the Geotechnical Section based on its field investigation. At a maximum, the back slope typically will not exceed 0.25:1. For large cuts, benching of the back slope may be required.

(6) Fill Slopes (Rock). In rock fills over 3.0 m high, the typical fill slope is 1.5:1. In rock fills ≤ 3.0 m, the typical slope is 6:1.

(7) Superelevation Rate. See Section 9.3 for superelevation rates based on design speed and curve radii.

(8) Maximum Grade (Mountainous). Gradients of up to 7% may be provided with approval by the Preconstruction Engineer. FHWA approval may also be required.

(9) Minimum Vertical Clearance. The clearances apply to a freeway passing under a bridge. The minimum clearance includes a 150 mm additional allowance for future overlays.

Figure 12-3

GEOMETRIC DESIGN CRITERIA FOR RURAL PRINCIPAL ARTERIALS (National Highway System — Non Interstate)

Design Element			Manual Section	Design Criteria		
Design Controls	Design Forecast Year (Geometrics)		8.4	20 Years (1)		
	*Design Speed	Level	8.3	110 km/h		
		Rolling		100 km/h		
		Mountainous		80 km/h		
	Level of Service		8.4	Level/Rolling: B Mountainous: C		
Roadway Elements	*Travel Lane Width		11.2	3.6 m (2)		
	*Shoulder Width		11.2	Varies (2)		
	Cross Slope	*Travel Lane	11.2	2%		
		Shoulder		2%		
	Median Width		11.3	Varies (3)		
Earth Cut Sections	Inslope		11.4	6:1 (Width: 3.0 m)		
	Ditch	Width	11.4	3.0 m Min.		
		Slope		20:1 towards back slope		
	Back Slope; Cut Depth at SlopeStake (4)	0 - 1.5 m	11.4	5:1		
		1.5 m - 3.0 m		Level/Rolling: 4:1; Mountainous: 3:1		
		3.0 m - 4.5 m		Level/Rolling: 3:1; Mountainous: 2:1		
		4.5 m – 6.0 m		Level/Rolling: 2:1; Mountainous: 1.5:1		
		> 6.0 m		1.5:1		
Earth Fill Slopes	Fill Height at Slope Stake (5)	0 - 3.0 m	11.4	6:1		
		3.0 m - 6.0 m		4:1		
		6.0 m - 9.0 m		3:1		
		> 9.0 m		2:1		
Alignment Elements	DESIGN SPEED		N/A	80 km/h	100 km/h	110 km/h
	*Stopping Sight Distance	Desirable	8.6	**140 m**	**210 m**	**250 m**
		Minimum		120 m	160 m	180 m
	Passing Sight Distance		8.6	550 m	675 m	750 m
	*Minimum Radius (e=8.0%)		9.2	230 m	395 m	500 m
	*Superelevation Rate (6)		9.3	e_{max} = 8.0%		
	*Vertical Curvature (K-value)	Crest	10.5	D: **49** M: 36	D: **110** M: 64	D: **155** M: 81
		Sag		D: **33** M: 27	D: **52** M: 38	D: **63** M: 44
	*Maximum Grade	Level	10.3	3%		
		Rolling		4%		
		Mountainous		7%		
	Mimimum Vertical Clearance (7)		10.6	5.05 m		

* Controlling design criteria (see Section 8.8). D: Desirable M: Minimum

GEOMETRIC DESIGN CRITERIA FOR RURAL PRINCIPAL ARTERIALS (National Highway System — Non Interstate)

Footnotes to Figure 12-3

(1) Design Forecast Year (Geometrics). For overlay and widening projects, the design year for geometrics is based on the design analysis period used for the pavement design, with 8 years as a minimum design forecast year.

(2) Travel Lane/Shoulder Width. See the accompanying Route Segment Map to determine the applicable roadway width for the facility under design. Reconstruction projects will be designed in accordance with the criteria in Figure 12-3. **For pavement preservation projects**, the objective is to provide the maximum roadway width. This is accomplished by the following:

a. If the existing width exceeds the Route Segment width, the overlay should be accommodated by reducing the top width. If accommodating the overlay would result in a roadway width less than the Route Segment width, narrow the roadway width to a width equal to or greater than the Route Segment width, before steeping the inslopes.

b. If the overlay will result in a roadway width less than the Route Segment width, steepen the surfacing inslopes to no steeper than 4:1 to maximize the roadway width.

c. If the Route Segment width cannot be achieved with surfacing inslopes no steeper than 4:1, the roadway width may be reduced. In no case can the roadway width be reduced to less than 8.4 m.

If widening (other than inslope dressing) is necessary to provide at least an 8.4 m roadway width with 4:1 surfacing inslopes, the project should be considered an "overlay and widening" project, and the roadway should be widened to the criteria in the accompanying Route Segment Map. This does not preclude some earthwork for safety purposes.

If 25% of an overlay and widening project or pavement preservation project requires intermittent reconstruction, then reconstruct the entire project to meet the criteria in Figure 12-3.

(3) Median Width. For two-way, left-turn lanes in rural conditions, the minimum width is 4.2 m. See Section 11.3 for additional information on median widths.

(4) Cut Slopes (Rock). The back slope through rock cut sections will be determined by the Geotechnical Section based on its field investigation. At a maximum, the back slope typically will not exceed 0.25:1. For large cuts, benching of the back slope may be required.

(5) Fill Slopes (Rock). In rock fills over 3.0 m high, the typical fill slope is 1.5:1. In rock fills ≤ 3.0 m, the typical slope is 6:1.

(6) Superelevation Rate. See Section 9.3 for superelevation rates based on design speed and curve radii.

(7) Minimum Vertical Clearance. The clearances apply to the arterial passing under a bridge. The minimum clearance includes a 150 mm additional allowance for future overlays.

Route Segment Plan
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Route Segment Plan
(Freeways/Principal Arterials)
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Figure 12-4

GEOMETRIC DESIGN CRITERIA FOR RURAL MINOR ARTERIALS (Non-NHS — Primary)

Design Element			Manual Section	Design Criteria		
Design Controls	Design Forecast Year (Geometrics)		8.4	20 Years (1)		
	*Design Speed	Level	8.3	100 km/h		
		Rolling		90 km/h		
		Mountainous		70 km/h		
	*Level of Service		8.4	Level/Rolling: B Mountainous: C		
Roadway Elements	*Travel Lane Width		11.2	3.6 m (2)		
	*Shoulder Width		11.2	Varies (2)		
	Cross Slope	*Travel Lane	11.2	2%		
		Shoulder		2%		
	Median Width		11.3	Varies (3)		
Earth Cut Sections	Inslope		11.4	6:1 (Width: 3.0 m)		
	Ditch	Width	11.4	3.0 M Min.		
		Slope		20:1 towards back slope		
	Back Slope; Cut Depth at Slope Stake (4)	0 - 1.5 m	11.4	5:1		
		1.5 m - 3.0 m		Level/Rolling: 4:1; Mountainous: 3:1		
		3.0 m - 4.5 m		Level/Rolling: 3:1; Mountainous: 2:1		
		4.5 m - 6.0 m		Level/Rolling: 2:1; Mountainous: 1.5:1		
		> 6.0 m		1.5:1		
Earth Fill Slopes	Fill Height at Slope Stake (5)	0 - 3.0 m	11.4	6:1		
		3.0 m - 6.0 m		4:1		
		6.0 m - 9.0 m		3:1		
		> 9.0 m		2:1		
Alignment Elements	DESIGN SPEED		N/A	70 km/h	90 km/h	100 km/h
	*Stopping Sight Distance	Desirable	8.6	**120 m**	**170 m**	**210 m**
		Minimum		100 m	140 m	160 m
	Passing Sight Distance		8.6	490 m	615 m	675 m
	*Minimum Radius (e=8.0%)		9.2	175 m	305 m	395 m
	*Superelevation Rate (6)		9.3	e_{max} = 8.0%		
	*Vertical Curvature (K-value)	Crest	10.5	D: **36** M: 25	D: **72** M: 49	D: **110** M: 64
		Sag		D: **27** M: 22	D: **41** M: 33	D: **52** M: 38
	*Maximum Grade	Level	10.3	3%		
		Rolling		4%		
		Mountainous		7%		
	*Minimum Vertical Clearance (7)		10.6	5.05 m		

* Controlling design criteria (see Section 8.8). D: Desirable M: Minimum

GEOMETRIC DESIGN CRITERIA FOR RURAL MINOR ARTERIALS (Non-NHS — Primary)

Footnotes to Figure 12-4

(1) Design Forecast Year (Geometrics). For overlay and widening projects, the design year for geometrics is based on the design analysis period used for the pavement design, with 8 years as a minimum design forecast year.

(2) Travel Lane/Shoulder Width. See the accompanying Route Segment Map to determine the applicable roadway width for the facility under design. Reconstruction projects will be designed in accordance with the criteria in Figure 12-4. **For pavement preservation projects**, the objective is to provide the maximum roadway width. This is accomplished by the following:

a. If the existing width exceeds the Route Segment width, the overlay should be accommodated by reducing the top width. If accommodating the overlay would result in a roadway width less than the Route Segment width, narrow the roadway width to a width equal to or greater than the Route Segment width, before steepening the inslopes.

b. If the overlay will result in a roadway width less than the Route Segment width, steepen the surfacing inslopes to no steeper than 4:1 to maximize the roadway width.

c. If the Route Segment width cannot be achieved with surfacing inslopes no steeper than 4:1, the roadway width may be reduced. In no case can the roadway width be reduced to less than 8.4 m.

If widening (other than inslope dressing) is necessary to provide at least an 8.4 m roadway width with 4:1 surfacing inslopes, the project should be considered an "overlay and widening" project, and the roadway should be widened to the criteria in the accompanying Route Segment Map. This does not preclude some earthwork for safety purposes.

If 25% of an overlay and widening project or pavement preservation project requires intermittent reconstruction, then reconstruct the entire project to meet the criteria in Figure 12-4.

(3) Median Width. For two-way, left-turn lanes in rural conditions, the minimum width is 4.2 m. See Section 11.3 for additional information on median widths.

(4) Cut Slopes (Rock). The back slope through rock cut sections will be determined by the Geotechnical Section based on its field investigation. At a maximum, the back slope typically will not exceed 0.25:1. For large cuts, benching of the back slope may be required.

(5) Fill Slopes (Rock). In rock fills over 3.0 m high, the typical fill slope is 1.5:1. In rock fills ≤ 3.0 m, the typical slope is 6:1.

(6) Superelevation Rate. See Section 9.3 for superelevation rates based on design speed and curve radii.

(7) Minimum Vertical Clearance. The clearances apply to the arterial passing under a bridge. The minimum clearance includes a 150 mm additional allowance for future overlays.

Route Segment Plan
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Figure 12-5

GEOMETRIC DESIGN CRITERIA FOR RURAL COLLECTOR ROADS
(Non-NHS — Secondary)

	Design Element		Manual Section	Design Criteria				
Design Controls	Design Forecast Year (Geometrics)		8.4	20 Years (1)				
	*Design Speed	Level	8.3	100 km/h				
		Rolling		80 km/h				
		Mountainous		70 km/h				
	Level of Service		8.4	Desirable: **B** Minimum: C				
Roadway Elements	DESIGN YEAR TRAFFIC	Current AADT	N/A	0-299	300-999	1000-1999	2000-3000	> 3000
		DHV		50-99	100-199	200-299	300-400	>400
	*Roadway Width (Travel Lanes & Shoulders) (2)		11.2	7.2 m	8.4 m	9.6 m	10.8 m	12.0 m
	Cross Slope	*Travel Lane	11.2	2%				
		Shoulder		2%				
	Median Width		11.3	Varies (3)				
Earth Cut Section	Inslope		11.4	DHV˙ 200 — 6:1 (Width: 3.0 m) DHV < 200 — 4:1 (Width: 2.0 m)				
	Ditch (4)	Width	11.4	3.0 m Min.				
		Slope		20:1 towards back slope				
	Back Slope; Cut Depth at Slope Stake (5)	0 - 1.5 m	11.4	5:1				
		1.5 m - 3.0 m		Level/Rolling: 4:1; Mountainous: 3:1				
		3.0 m - 4.5 m		Level/Rolling: 3:1; Mountainous: 2:1				
		4.5 m – 6.0 m		Level/Rolling: 2:1; Mountainous: 1.5:1				
		> 6.0 m		1.5:1				
Earth Fill Slopes	Fill Height at Slope Stake (6)	0 - 3.0 m	11.4	DHV˙ 200 — 6:1 DHV < 200 — 4:1				
		3.0 m - 6.0 m		DHV˙ 200 — 4:1 DHV < 200 — 3:1				
		6.0 m - 9.0 m		3:1				
		> 9.0 m		2:1				
Alignment Elements	DESIGN SPEED		N/A	70 km/h		80 km/h		100 km/h
	*Stopping Sight Distance	Desirable	8.6	**120 m**		**140 m**		**210 m**
		Minimum		100 m		120 m		160 m
	Passing Sight Distance		8.6	490 m		550 m		675 m
	*Minimum Radius (e=8.0%)		9.2	175 m		230 m		395 m
	*Superelevation Rate (7)		9.3	emax = 8.0%				
	*Vertical Curvature (K-value)	Crest	10.5	D: **36**	M: 25	D: **49**	M: 36	D: **110** M: 64
		Sag		D: **27**	M: 22	D: **33**	M: 27	D: **52** M: 38
	*Maximum Grade	Level	10.3	5%				
		Rolling		7%				
		Mountainous		10%				
	*Minimum Vertical Clearance (8)		10.6	5.05 m				

* Controlling design criteria (see Section 8.8). D: Desirable M: Minimum

GEOMETRIC DESIGN CRITERIA FOR RURAL COLLECTOR ROADS (Non-NHS — Secondary)

Footnotes to Figure 12-5

(1) Design Forecast Year (Geometrics). For overlay and widening projects, the design year for geometrics is based on the design analysis period used for the pavement design, with 8 years as a minimum design forecast year.

(2) Travel Lane/Shoulder Width. Reconstruction projects will be designed in accordance with the criteria in Figure 12-5. **For pavement preservation projects**, the objective is to provide the maximum roadway width. This is accomplished by the following:

a. If the existing top width exceeds 7.2 m, the overlay should be accommodated by reducing the roadway to a width greater than or equal to 7.2 m.

b. If the overlay will result in a roadway width less than 7.2 m, steepen the surfacing inslopes to no steeper than 4:1 to maximize the roadway width.

If widening (other than inslope dressing) is necessary to provide at least a 7.2 m roadway width with 4:1 surfacing inslopes, the project should be considered an "overlay and widening" project. Consequently, the roadway should be widened in accordance with the criteria in Figure 12-5.

If the roadway width is less than 8.4 m, add 0.6 m to each side of the roadway where a barrier is located.

If 25% of the overlay and widening project or pavement preservation project requires intermittent reconstruction, then the entire project should be reconstructed to meet the criteria in Figure 12-5.

(3) Median Width. For two-way, left-turn lanes in rural conditions, the minimum width is 4.2 m. See Section 11.3 for additional information on median widths.

(4) Ditch. A V-ditch may be used where backslopes are 4:1 or flatter. For backslopes steeper than 4:1, place the toe of the backslope outside the clear zone.

(5) Cut Slopes. The designer should attempt to locate back slopes steeper than 4:1 outside the clear zone. The back slope through rock cut sections will be determined by the Geotechnical Section based on its field investigation. At a maximum, the back slope typically will not exceed 0.25:1. For large cuts, benching of the back slope may be required.

(6) Fill Slopes (Rock). In rock fills over 3.0 m high, the typical fill slope is 1.5:1. In rock fills ≤ 3.0 m, the typical slope is 6:1.

(7) Superelevation Rate. See Section 9.3 for superelevation rates based on design speed and curve radii.

(8) Minimum Vertical Clearance. The clearances apply to the collector passing under a bridge. The minimum clearance includes a 150 mm additional allowance for future overlays.

Figure 12-6

GEOMETRIC DESIGN CRITERIA FOR RURAL LOCAL ROADS (Off-System BR Projects)

Design Element			Manual Section	Design Criteria		
Design Controls	Current ADT		N/A	≤ 300 (1)		
	*Design Speed	Paved Surface	8.3	80 km/h (2)		
		Gravel Surface		70 km/h (2)		
Roadway Elements	*Minimum Roadway Width		11.2	7.2 m (3)		
	Cross Slope	*Travel Lane	11.2	Paved: 2% Gravel: 3%		
		Shoulder		Paved: 2% Gravel: 3%		
	Median Width		11.3	Varies (4)		
Earth Cut Sections	Inslope		11.4	4:1		
	Ditch		11.4	V-Ditch (0.3 m Depth)		
	Back Slope; Cut Depth at Slope Stake (5)	0 - 1.5 m	11.4	4:1		
		1.5 m - 3.0 m		Level/Rolling: 3:1; Mountainous: 2:1		
		3.0 m - 6.0 m		Level/Rolling: 2:1; Mountainous: 1.5:1		
		> 6.0 m		1.5:1		
Earth Fill Slopes	Fill Height at Slope Stake (6)	0 - 3.0 m	11.4	4:1		
		3.0 – 6.0 m		2:1		
		> 6.0 m		1.5:1		
Alignment Elements	DESIGN SPEED		N/A	50 km/h	70 km/h	80 km/h
	*Stopping Sight Distance	Desirable	8.6	**70 m**	**120 m**	**140 m**
		Minimum		60 m	100 m	120 m
	Passing Sight Distance		8.6	350 m	490 m	550 m
	*Minimum Radius (e=8.0%)		9.2	80 m	175 m	230 m
	*Superelevation Rate (7)		9.3	emax = 8.0%		
	*Vertical Curvature (K-value)	Crest	10.5	D: **13** M: 9	D: **36** M: 25	D: **49** M: 36
		Sag		D: **14** M: 11	D: **27** M: 22	D: **33** M: 27
	*Maximum Grade	Level	10.3	7%	7%	6%
		Rolling		10%	9%	8%
		Mountainous		10%	10%	10%
	*Minimum Vertical Clearance (8)		10.6	4.40 m		

* Controlling design criteria (see Section 8.8). D: Desirable M: Minimum

GEOMETRIC DESIGN CRITERIA FOR RURAL LOCAL ROADS (Off-System BR Projects)

Footnotes to Figure 12-6

(1) AADT. For local rural roads with AADT > 300 and/or functionally classified as a rural collector, the design criteria for rural collector roads should be used (Figure 12-5).

(2) Design Speed. See Section 8.3 for selection of design speed. For local roads requiring a higher design speed, the criteria for rural collector roads should be used (Figure 12-5). The 50 km/h design speed should only be used if the adjacent terrain presents obstacles that render the use of a higher design speed impractical. A formal design exception for design speed is not required for rural local roads. However, deviation from the design speeds in Figure 12-6 must be documented in the PFR, AR and SOW reports.

(3) Roadway Width. The bridge width, adjacent paved traveled way width and county standards should be considered when establishing a roadway width, if greater than the minimum.

(4) Median Width. For two-way, left-turn lanes in rural conditions, the minimum width is 4.2 m. See Section 11.3 for additional information on median widths.

(5) Cut Slopes (Rock). The back slope through rock cut sections will be determined by the Geotechnical Section based on its field investigation. At a maximum, the back slope typically will not exceed 0.25:1. For large cuts, benching of the back slope may be required.

(6) Fill Slopes. In rock fills over 3.0 m high, the typical fill slope is 1.5:1. In rock fills ≤ 3.0 m, the typical fill slope is 4:1. In earth fills where the fill depth > 6.0 m, the use of steeper than 1.5:1 slopes may be used if justified by a slope stability analysis.

(7) Superelevation Rate. See Section 9.3 for superelevation rates based on design speed and curve radii.

(8) Minimum Vertical Clearance. The clearances apply to the local road passing under a bridge. The minimum clearance includes a 150 mm additional allowance for future overlays.

Figure 12-7

GEOMETRIC DESIGN CRITERIA FOR URBAN PRINCIPAL ARTERIALS (National Highway System — Non Interstate)

	Design Element		Manual Section	2-Lane		Multi-lane	
				Curbed	Uncurbed	Curbed	Uncurbed
Design Controls	Design Forecast Year (Geometrics)		8.4	20 Years (1)		20 Years (1)	
	*Design Speed		8.3	70 km/h	70-80 km/h	70 km/h	70-90 km/h
	Level of Service		8.4	Desirable: **B** Minimum: **C**		Desirable: **B** Minimum: **C**	
Roadway Elements	*Shoulder Width	Outside	11.2	0.6 m	2.4 m	0.6 m	2.4 m
		Inside		N/A		0.6 m	1.0 m
	Cross Slope	*Travel Lane	11.2	2% Typical (2)	2%	2% Typical (2)	2%
		Shoulder		2% Typical (2)	2%	2% Typical (2)	2%
	Median Width		11.3	N/A		Flush: 1.2 m - 5.0 m (3) Raised: 6.0 m (3)	
	TWLTL Width		11.2	4.8 m		4.8 m	
Earth Cut Sections	Ditch	Width	11.4	N/A	3.0 m Min.	N/A	3.0 m
		Slope		N/A	20:1 towards back slope	N/A	20:1 towards back slope
	Back Slope; Cut Depth at Slope Stake (4)	0 - 1.5 m	11.4	As Flat As Practical	5:1	As Flat As Practical	5:1
		1.5 m - 3.0 m			L/R: 4:1 Mt: 3:1		3:1
		3.0 m - 4.5 m			L/R: 3:1 Mt: 2:1		2:1
		4.5 m – 6.0 m			L/R: 2:1 Mt: 1.5:1		1.5:1
		> 6.0 m			1.5:1		1.5:1
Earth Fill Slopes	Fill Height at Slope Stake (5)	0 - 3.0 m	11.4	As Flat As Practical	6:1	As Flat As Practical	6:1
		3.0 m - 6.0 m			4:1		4:1
		6.0 m - 9.0 m			3:1		3:1
		> 9.0 m			2:1		2:1
Alignment Elements (8)	DESIGN SPEED		N/A	70 km/h	80 km/h	90 km/h	
	*Stopping Sight Distance	Desirable	8.6	**120 m**	**140 m**	**170 m**	
		Minimum		100 m	120 m	140 m	
	*Minimum Radius (@ e_{max})		9.2	190 m	230 m	305 m	
	*Superelevation Rate (6)		9.3 & 9.4	e_{max} = 4.0%	e_{max} = 8.0%		
	*Vertical Curvature (K-value)	Crest	10.5	D: **36** **M**: 25	D: **49** **M**: 36	D: **72** **M**: 49	
		Sag		D: **27** **M**: 22	D: **33** **M**: 27	D: **41** **M**: 33	
	*Maximum Grade	Level	10.3	6%	6%	5%	
		Rolling		7%	7%	6%	
		Mountainous		9%	9%	8%	
	*Minimum Vertical Clearance (7)		10.6	5.05 m			

* Controlling design criteria (see Section 8.8).

L/R: Level/Rolling
Mt: Mountainous
D: Desirable
M: Minimum

GEOMETRIC DESIGN CRITERIA FOR URBAN PRINCIPAL ARTERIALS (National Highway System — Non Interstate))

Footnotes to Figure 12-7

(1) Design Forecast Year (Geometrics). For overlay and widening projects, the design year for geometrics is based on the design analysis period used for the pavement design, with 8 years as a minimum design forecast year.

(2) Cross Slopes (Curbed). The cross slope may be between 1% and 4%, depending on site conditions.

(3) Median Width. See Section 11.3 for more information on median width.

(4) Cut Slopes. For curbed sections, see the typical section figures in Section 11.7. The back slope through rock cut sections will be determined by the Geotechnical Section based on its field investigation. At a maximum, the back slope typically will not exceed 0.25:1. For large cuts, benching of the back slope may be required.

(5) Fill Slopes. For curbed sections, see the typical section figures in Section 11.7. In rock fills over 3.0 m high, the typical fill slope is 1.5:1. In rock fills ≤ 3.0 m, the typical slope is 6:1.

(6) Superelevation Rate. See Section 9.3 or 9.4 for superelevation rates based on design speed and curve radii.

(7) Minimum Vertical Clearance. The clearances apply to the arterial passing under a bridge. The minimum clearance includes a 150 mm additional allowance for future overlays.

(8) Alignment Elements. If 25% or more of an overlay and widening project or pavement preservation project requires intermittent reconstruction, then reconstruct the entire alignment to meet the criteria in Figure 12-7.

Figure 12-8

GEOMETRIC DESIGN CRITERIA FOR URBAN MINOR ARTERIALS (Non-NHS)

Design Element			Manual Section	2-Lane		Multi-lane	
				Curbed	Uncurbed	Curbed	Uncurbed
Design Controls	Design Forecast Year (Geometrics)		8.4	20 Years (1)		20 Years (1)	
	*Design Speed		8.3	60 km/h	60-70 km/h	60 km/h	60-80 km/h
	Level of Service		8.4	Desirable: **B** Minimum: C		Desirable: **B** Minimum: C	
Roadway Elements	*Travel Lane Width		11.2	3.6 m		3.6 m	
	*Shoulder Width	Outside	11.2	0.6 m	D: **2.4 m** M:1.8 m	0.6 m	D: **2.4 m** M:1.8
		Inside		N/A		0.6 m	1.0 m
	Cross Slope	*Travel Lane	11.2	2% Typical (2)	2%	2% Typical (2)	2%
		Shoulder		2% Typical (2)	2%	2% Typical (2)	2%
	Median Width		11.3	N/A		Flush: 1.2 m - 5.0 m (3) Raised: 6.0 m (3)	
	TWLTL Width		11.2	4.8 m		4.8 m	
Earth Cut Slopes	Inslope		11.4	N/A	6:1	N/A	6:1
	Ditch	Width	11.4	N/A	3.0 m Min.	N/A	3.0 m
		Slope		N/A	20:1 towards back slope	N/A	20:1 towards back slope
	Back Slope; Cut Depth at Slope Stake (4)	0 - 1.5 m	11.4	As Flat As Practical	5:1	As Flat As Practical	5:1
		1.5 m - 3.0 m			L/R:4:1 Mt: 3:1		3:1
		3.0 m - 4.5 m			L/R:3:1 Mt: 2:1		2:1
		4.5 M – 6.0 m			L/R: 2:1 Mt:1.5:1		1.5:1
		> 6.0 m			1.5:1		1.5:1
Earth Fill Slopes	Fill Height at Slope Stake (5)	0 - 3.0 m	11.4	As Flat As Practical	6:1	As Flat As Practical	6:1
		3.0 m - 6.0 m			4:1		4:1
		6.0 m - 9.0 m			3:1		3:1
		> 9.0 m			2:1		2:1

Alignment Elements (8)	DESIGN SPEED		N/A	60 km/h	70 km/h	80 km/h
	*Stopping Sight Distance	Desirable	8.6	**90 m**	**120 m**	**140 m**
		Minimum		80 m	100 m	120 m
	*Minimum Radius (@ emax)		9.2	125 m	190 m	230 m
	*Superelevation Rate (6)		9.3 & 9.4	e_{max} = 4.0%		e_{max} = 8.0%
	*Vertical Curvature (K-value)	Crest	10.5	D: **21** M: 16	D: **36** M: 25	D: **49** M: 36
		Sag		D: **19** M: 16	D: **27** M: 22	D: **33** M: 37
	*Maximum Grade	Level	10.3	7%	6%	6%
		Rolling		8%	7%	7%
		Mountainous		10%	9%	9%
	*Minimum Vertical Clearance (7)		10.6	5.05 m		

* Controlling design criteria (see Section 8.8).

L/R: Level/Rolling
Mt: Mountainous

D: Desirable
M: Minimum

GEOMETRIC DESIGN CRITERIA FOR URBAN MINOR ARTERIALS (Non-NHS)

Footnotes to Figure 12-8

(1) Design Forecast Year (Geometrics). For overlay and widening projects, the design year for geometrics is based on the design analysis period used for the pavement design, with 8 years as a minimum design forecast year.

(2) Cross Slopes (Curbed). The cross slope may be between 1% and 4%, depending on site conditions.

(3) Median Width. See Section 11.3 for more information on median width.

(4) Cut Slopes. For curbed sections, see the typical section figures in Section 11.7. The back slope through rock cut sections will be determined by the Geotechnical Section based on its field investigation. At a maximum, the back slope typically will not exceed 0.25:1. For large cuts, benching of the back slope may be required.

(5) Fill Slopes. For curbed sections, see the typical section figures in Section 11.7. In rock fills over 3.0 m high, the typical fill slope is 1.5:1. In rock fills ≤ 3.0 m, the typical slope is 6:1.

(6) Superelevation Rate. See Section 9.3 or 9.4 for superelevation rates based on design speed and curve radii.

(7) Minimum Vertical Clearance. The clearances apply to the arterial passing under a bridge. The minimum clearance includes a 150 mm additional allowance for future overlays.

(8) Alignment Elements. If 25% or more of an overlay and widening project or pavement preservation project requires intermittent reconstruction, then reconstruct the entire alignment to meet the criteria in Figure 12-8.

Figure 12-9

GEOMETRIC DESIGN CRITERIA FOR URBAN COLLECTOR STREETS (Non-NHS)

Design Element			Manual Section	Design Criteria	
				Curbed	Uncurbed
Design Contols	Design Forecast Year (Geometrics)		8.4	20 Years (1)	
	*Design Speed		8.3	50 km/h	50-60 km/h
	Level of Service		8.4	Desirable: **C** Minimum: D	
Roadway Elements	* Travel Lane Width		11.2	3.6 m	
	*Shoulder Width	Outside	11.2	0.6 m	D: **2.4 m** M: 1.8 m
		Inside		N/A	
	Cross Slope	*Travel Lane	11.2	2% Typical (2)	2%
		Shoulder		2% Typical (2)	2%
	TWLTL Width		11.2	4.8 m	
Earth Cut Sections	Inslope		11.4	N/A	6:1
	Ditch	Width	11.4	N/A	3.0 m Min.
		Slope		N/A	20:1 towards back slope
	Back Slope; Cut Depth at Slope Stake (3)	0 - 1.5 m	11.4	As Flat As Practical	5:1
		1.5 m - 3.0 m			L/R: 4:1 Mt: 3:1
		3.0 m - 4.5 m			L/R: 3:1 Mt: 2:1
		4.5 m – 6.0 m			L/R: 2:1 Mt: 1.5:1
		> 6.0 m			1.5:1
Earth Fill Sections	Fill Height at Slope Stake (4)	0 - 3.0 m	11.4	As Flat As Practical	6:1
		3.0 m - 6.0 m			4:1
		6.0 m - 9.0 m			3:1
		> 9.0 m			2:1
Alignment Elements (7)	DESIGN SPEED		N/A	50 km/h	60 km/h
	*Stopping Sight Distance	Desirable	8.6	**70 m**	**90 m**
		Minimum		60 m	80 m
	*Minimum Radius (@ e_{max})		9.2	80 m	125 m
	*Superelevation Rate (5)		9.4	e_{max} = 4.0%	
	*Vertical Curvature (K-value)	Crest	10.5	D: **13** M: 9	D: **21** M: 16
		Sag		D: **14** M: 11	D: **19** M: 16
	*Maximum Grade	Level	10.3	9%	9%
		Rolling		10%	10%
		Mountainous		10%	10%
	*Minimum Vertical Clearance (6)		10.6	5.05 m	

* Controlling design criteria (see Section 8.8).

L/R: Level/Rolling
Mt: Mountainous

D: Desirable
M: Minimum

GEOMETRIC DESIGN CRITERIA FOR URBAN COLLECTOR STREETS (Non-NHS)

Footnotes to Figure 12-9

(1) Design Forecast Year (Geometrics). For overlay and widening projects, the design year for geometrics is based on the design analysis period used for the pavement design, with 8 years as a minimum design forecast year.

(2) Cross Slopes (Curbed). The cross slope may be between 1% and 4%, depending on site conditions.

(3) Cut Slopes. For curbed sections, see the typical section figures in Section 11.7. The back slope through rock cut sections will be determined by the Geotechnical Section based on its field investigation. At a maximum, the back slope typically will not exceed 0.25:1. For large cuts, benching of the back slope may be required.

(4) Fill Slopes. For curbed sections, see the typical section figures in Section 11.7. In rock fills over 3.0 m high, the typical fill slope is 1.5:1. In rock fills ≤ 3.0 m, the typical slope is 6:1.

(5) Superelevation Rate. See Section 9.4 for superelevation rates based on design speed and curve radii.

(6) Minimum Vertical Clearance. The clearances apply to the collector street passing under a bridge. The minimum clearance includes a 150 mm additional allowance for future overlays.

(7) Alignment Elements. If 25% or more of an overlay and widening project or pavement preservation project requires intermittent reconstruction, then reconstruct the entire alignment to meet the criteria in Figure 12-9.